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## **Factorial Study of Speed of Response in Simple Cancellation Tasks \***

By DALE W. DYSINGER

### INTRODUCTION

Several factor analyses have been conducted with the objective of isolating the aspects of the stimulus situation affecting performance on simple tasks presented under the set for speed as well as accuracy. The factors in this area of performance have not proved to be as stable as have some in the areas of verbal, spatial, and numerical skills. In a recent factor analysis, [1], several new hypotheses were presented to account for the apparent instability of the perceptual-speed domain. One of these hypotheses was that three or more linearly independent factors must be postulated to account for the variance of these perceptual-speed tasks. Further study of the implications of these hypotheses seems to be warranted in the light of the stability or invariance which now seems probable.

### THE PROBLEM

One of the major problems suggested by recent investigations is the identification of the sources of variance accounting for what has been designated the "L" factor. Suggestions have been made that this factor can be interpreted as "speed of recognition of a predetermined symbol or symbols in a context of irrelevant distractors." [1] There are indications, however, that this hypothesized factor might be restricted to such highly practiced materials as letters, digits, and words rather than associated with the more general class of discrete visual configurations. Further study in repeated simple choice discrimination tasks of changes in performance attributable to changes in the characteristics of the task appears necessary if useful generalizations regarding the relevant variables in test performance are to be made. Five hypotheses expressing relevant individual differences in test performance as "factors" associated with the stimulus situation were therefore formulated for investigation. These hypotheses were as follows:

1. A factor, herein designated "L," interpreted as speed of recognition of a predetermined, highly practiced symbol or symbols in a context of readily discriminable distractors, can be determined.

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2. A second and new factor, designated "P," interpreted as speed of recognition of a predetermined but novel configuration in a context of discrete but similar distractors, can be determined.

3. A third and new factor, designated "C," interpreted as a speed of classification of readily discriminable configurations into two or more categories, will be defined by tasks requiring a specified response to every discrete visual configuration. The response made classifies the stimulus figure into one of two or more predetermined categories.

4. The "H" factor, previously reported as speed of controlled hand-finger movement, is linearly independent of, but correlated with, the three factors noted above.

5. The four speed factors of this battery will be correlated and will define a general speed factor. This general speed factor will appear either as a second-order general factor or as a first-order general factor. This general speed factor may well be the common source of variance reported by some investigators as "*the perceptual-speed*" factor.

#### THE INVESTIGATION

To investigate these hypotheses a battery of ten paper and pencil tests was constructed and administered to a sample of one hundred sixty-one volunteers from the introductory psychology course at The State University of Iowa.

Five of the tests have been used in the same, or slightly modified form, in other investigations of the perceptual-speed domain. The two tests, Letter A and First Digit Cancellation, which had high loadings on the "L" factor in another study, [1], were incorporated in this battery. Three tests requiring the cancellation of geometric or pictorial materials were included to test the hypothesis concerning the "P" factor. These tests have been labelled Triangles, Simple Figures, and Identical Forms. Three tests were included to investigate the hypothesized "complete coding" or "classification" factor, "C"; these tests were entitled Typewriter Signs, Letters c, v, and Curved and Straight Letters. These tests require the subject to classify the stimuli into two categories; for example he must circle all symbols of one designated class and cross out all the other symbols. Two tests, Writing X's and Writing Words, previously used to define the hand-finger dexterity factor, were included to indicate the role of speed of controlled movement on the several perceptual-speed tests used in the battery. The list of variables with time limits and scoring formulae is presented in Table 1.

The normalized test score distributions were transformed to a

**Table 1**  
The Battery of Variables

Code No. <sup>1</sup>	Test Name	Testing Time Limits		Scoring Formula
		Min.	Sec.	
1	Letter A	2	40	R
2	Triangles	2	--	R
3	Curved and Straight Letters	3	30	R
4	Writing X's	--	30	No. X's
5	Simple Figures	2	20	R
6	Typewriter Signs	3	30	R
7	First Digit Cancellation	3	--	R
8	Letters c, v	3	--	R
9	Identical Forms	3	--	4R-W
10	Writing Words	1	--	No. Words

<sup>1</sup> The code number indicates the order of administration.

single digit code, zero to nine inclusive, and Pearson product-moment correlations were calculated for all the test intercorrelations. Thurstone's complete centroid method of factoring with estimated communalities was used in analyzing the data. Three cycles were necessary to stabilize the communalities. Four factors were extracted. Radial rotations of the centroid factor matrix to the simple structure solution, as specified by Thurstone, [5], were made. Since this simple structure solution contained one highly oblique plane, an alternative position of this plane was determined; the alternate solution located the plane orthogonal to the other three planes of the system. The rotated factor matrix is presented in Table 2; the plane arbitrarily set orthogonal is designated

**Table 2**  
The Rotated Factor Matrix<sup>1</sup>

Test	C	H	P	L	L <sup>1</sup>
1	—10	01	—07	57	72
2	—02	—02	45	—06	24
3	61	00	28	—09	55
4	29	63	—05	—07	18
5	02	04	39	28	76
6	58	05	—07	10	55
7	09	00	09	48	86
8	54	—06	03	18	69
9	05	02	51	03	50
10	—01	59	05	08	26

<sup>1</sup> Values have been multiplied by 100 to eliminate the decimal point.

"L". The factors indicated by the rotated factor matrix will now be considered in terms of the hypotheses under investigation.

#### RESULTS AND INTERPRETATIONS

The three "complete coded" tests, Curved and Straight Letters (3), Typewriter Signs (6), and Letters c, v (8), are the only tests having loadings above .30 on the "C" factor. Although this factor has not been previously isolated, the tests were designed in terms of the hypothesis that such a factor would be defined by such tests. It is suggested that facility in these "complete coded" tasks may be associated with a freedom from, or resistance to, blocking or work inhibition effects. The factor transcends the type of content since tests containing both letters and symbols appear; the factor also appears with changes in the type of category used in the discrimination. The response required in these tasks precludes the rapid scanning work method and possibly "span of perception" feature which seem to be characteristic of the "L" factor. Further implications of this factor in relation to other similar tasks is being investigated by a study now in progress at the University of Iowa.

The "H" factor, interpreted as speed of controlled hand-finger movement, closely corresponds to the "H" factor reported previously. [1] The tests, Writing X's (4) and Writing Words (10), are the only tests that show significant loadings on this factor. These two tests were expected to locate the axis precisely; however, the location of the plane was indeterminate in one direction.

Only the three tests, Triangles (2), Simple Figures (5), and Identical Forms (9), that were constructed according to the "P" factor hypothesis have loadings above .30 on this factor. The hypothesis was that a new factor would be defined by responses to unfamiliar pictorial or geometric figures presented with discrete distractors such that verbalization of the key stimulus would not materially assist the discrimination required. The use of only three tests so similar in form, content, and operation does not preclude alternative interpretations of the results. To investigate the hypothesis that the familiarity of the materials is the crucial feature of the "P" factor, this battery was administered to the same sample forty-eight hours later. This hypothesis would require that on the second administration the correlation between the "P" factor and the "L" factor would be higher. The analysis of these data is now in progress. Another possible hypothesis is that the crucial process involves a facility in acquiring and utilizing a visual image of the key stimulus.

The "L" and "L<sup>1</sup>" factors will be discussed together since they represent alternate solutions of this factor. The "L" axis represents the simple structure solution while the "L<sup>1</sup>" axis was set orthogonal to the "C," "P," and "H" axes. Letter A (1) and First Digit Cancellation (7) were introduced into this battery to locate the "L" factor. The appearance of this factor defined by these two tests shows a desirable degree of stability in the perceptual-speed area. The results are consistent with the hypothesis that a factor would be defined by tests utilizing highly practiced symbols and distractors relatively dissimilar to, or readily discriminated from, the key figure. However, the interpretation of the "L" factor is complicated by the high correlations between the primary vectors of "L" and "C," (.61), and "L" and "P," (.63). The correlation matrix of the four primary vectors "C," "H," "P" and "L" was not of rank one, so no single general second-order factor could be determined. The "L<sup>1</sup>" vector as the alternate solution to the second-order general factor, represents a first-order general factor. Further investigation of the correspondence between "L<sup>1</sup>" and a second-order general factor would require the use of a larger battery of tests including such factors as Thurstone's "primary mental abilities" defined by other types of speeded and non-speeded tasks.

#### SUMMARY

In general, the results of this factor analysis were consistent with the hypotheses. Four factors were found as expected, and were defined by the tasks designed in terms of the original hypotheses. The tentative interpretations are reviewed below.

The "C" factor, defined by "complete coded" tasks, is considered to be a speed of classification of readily discriminable configurations into two or more categories. The "H" factor, interpreted as speed of controlled hand-finger movement, appeared as predicted. This factor seems to be relatively stable, for it has been reported in several investigations of perceptual-speed. A new factor "P" was defined in this battery. Two suggestions as to the sources of variance associated with this factor were presented. The "L" factor was defined by a highly oblique axis, so an alternative position of this factor, "L<sup>1</sup>," was introduced. The "L<sup>1</sup>" factor was considered to be a first-order general speed factor, but further investigation of this relationship is indicated. The definition of the factors in the perceptual-speed domain and the establishment of the relationship of this domain to other factors which have been isolated, are considered challenging tasks for further investigation.

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